

MAN-MACHINE INTERFACES IN HEALTH CARE

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The surgeon, like the pilot, is confronted with an ever increasing volume of voice, data and image input. Simultaneously, the surgeon must control a rapidly growing number of devices to deliver care to the patient. The broad disciplines of man-machine interface design, systems integration and teleoperation will play a role in the operating room of the future. The purpose of this communication is to report the incorporation of these design concepts into new surgical and laser delivery systems. A review of each general problem area and the systems under development to solve the problems follows.

Ophthalmology is a machine-dependent specialty embracing the patient-machine interface and the surgeon-machine interface. As many as fifteen independent systems may be used in the operating room during a surgical procedure. Each system is currently manually controlled creating an intensive operator interface environment. The surgical operating system known as the Ocular Connection Machine (OCM) has reduced the number of stopcocks, foot pedals, adapters, displays, controls and power cords by several orders of magnitude. Physiological analog parameters, including intraocular temperature and pressure, previously monitored with human interaction are now controlled by servo systems, while surgical analog parameters, i.e., cutting and thermal, are controlled by dual proportional positioning of the surgeon's foot. Multiple displays have been replaced by one thus reducing viewing time and errors. By reducing the amount of man-machine interactions, the system markedly reduces set-up time and clean-up time, as well as improving reliability, functionality and patient safety.

Laser treatment of the retina is an intensive man-machine task. The ophthalmologist must determine the area of treatment, aim the beam and fire while the patient is awake. The Laser Imaging Work Station (LIWS) currently under development alleviates much of the ophthalmologist-machine interaction and reduces the discomfort of the patient-machine interaction. The LIWS is an integrated system containing a high-speed digital correlation retinal tracker, an automated laser delivery system which controls laser power, wavelength, spot size, duration and location, and an expert system with algorithms to avoid the macula, optic nerve, vessels and previous photocoagulated areas. Surgeon interface occurs off-line whereby a patient treatment template is determined and down-loaded to the laser delivery system.

Real-time diagnostic imaging of a patient's eye is currently resolution limited, two-dimensional and user interaction intensive. A system is currently under development which provides quasi-real time stereo (3D) ultrasound and improved lateral resolution. Depth of the viewing volume within the eye (focal plane) is identical to current focus mechanisms used by ophthalmologists whereby a hand-held lens is moved forward and backward yielding different viewing planes (indirect ophthalmoscopy). This hand-eye coordination and resulting spatial information will be natural for ophthalmologists.

Utilization of advanced robotic systems in a teleoperation environment will enable microsurgons to improve present operations and allow those surgeons not as dexterous to perform operations not manageable with present systems. For example, epiretinal membranes too thin to remove without risk of macular holes would be a realizable target for the ophthalmic microsurgon. By applying 6 degrees-of- freedom in a coarse-fine strategy with translational resolutions of 10 to 20 microns, these techniques and others are made possible. The surgeon controls the bilateral robotic system through the surgeon-machine interface (SMI) which provides stiffness feedback by sensing force and position at the operating site and backdriving actuators within the SMI. Further sensing of optical, electrical and mechanical impedance at the operation site is fed back to the surgeon via the foot pedal interface, offering another realm of sensory feedback.